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### (54) Electric power generating device for vehicles

Vorrichtung zur Leistungserzeugung für Fahrzeuge

Dispositif de génération de puissance pour véhicules

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(73) Proprietor: DENSO CORPORATION  
Kariya-City, Aichi-Pref. (JP)

(72) Inventors:  
• Kusase, Shin  
Obu-city, Aichi-pref., 474 (JP)  
• Mitani, Kenzo  
Obu-city, Aichi-pref., 474 (JP)  
• Umeda, Atsushi  
Anjo-city, Aichi-pref., 446 (JP)  
• Sato, Hirohide  
Toyokawa-city, Aichi-pref., 442 (JP)

(74) Representative:  
Winter, Brandl, Fürniss, Hübner, Röss,  
Kaiser, Polte  
Partnerschaft  
Patent- und Rechtsanwaltskanzlei  
Alois-Steinecker-Strasse 22  
85354 Freising (DE)

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- IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, vol. 37, no. 6, 1 December 1990 pages 531-537, XP 000179416 AMMASAIGOUNDEN N ET AL 'MICROPROCESSOR-BASED VOLTAGE CONTROLLER FOR WIND-DRIVEN INDUCTION GENERATORS'
- PATENT ABSTRACTS OF JAPAN vol. 017 no. 334 (E-1387), 24 June 1993 & JP-A-05 038150 (TOSHIBA CORP) 12 February 1993,

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## Description

CROSS REFERENCE TO RELATED APPLICATION

- 5 [0001] This application is based upon and claims the benefit of priority of the prior Japanese Patent applications No. 6-9699 filed on January 31, 1994, No. 6-187307 filed on August 9, 1994 and No. 6-187321 filed on August 9, 1994.

BACKGROUND OF THE INVENTION10 1. Field of the Invention:

[0002] The present invention generally relates to an electric power generating device for vehicles. More particularly, the present invention relates to an electric power generating device for charging a battery for vehicles by using an induction machine.

15 2. Related Arts:

[0003] In the Japanese Unexamined Patent Publication (KOKAI) No. 63-302119, an induction type electric power generating device, which is driven by an exhaust gas turbine for vehicles, is disclosed. This induction type electric power generating device aims to give priority to the efficiency of the turbine and therefore operates within the rotation area of the best turbine efficiency by adjusting the slip thereof.

[0004] In the Japanese Unexamined Patent Publication (KOKAI) No. 2-87999, there is a proposal that the required slip state should be maintained by controlling the frequency of the inverter based on the revolution number (RPM) of the electric power generating device detected by an RPM sensor.

25 [0005] In the induction type electric power generating device proposed in the above publications, the electric power generating amount should be adjusted by detecting the RPM of the device and controlling the slip. However, in induction type electric power generating devices, unlike synchronous electric power generating devices, the exciting frequency is determined from the charging power source side. Characteristically, the torque, or the electric power generating amount significantly varies due to even slight change in the RPM (slip) in spite of the frequent, speedy speed variation of the slip caused by the variation of the engine RPM. Therefore, when an induction machine is applied to an electric power generating device for vehicles, there is a need to use a high-precision, high-responsive RPM sensor (speed sensor) to control the slip at a high speed and a high precision. This has been a major drawback of a conventional 3-phase synchronous electric power generating devices (alternators) in using induction type electric power generating devices as electric power generating devices for vehicles.

35 [0006] In particular, the above problem in controlling electric power generation by controlling the slip is more serious when the induction type electric power generating device is speed-increasingly driven by a belt for reducing the size and weight thereof or provided with multiple poles (8 poles or so) for increasing the frequency and speed.

[0007] Document EP-A-0 130 242 discloses an electric power generating device which can be used as induction motor as well as a generator. An induction type electric rotating machine includes an armature winding and a rotor working with an engine. A battery is charged by the electric power generator output from the armature winding. An inverter is connected with its alternating current side to an end of the armature winding while its direct current side is connected to the battery in order to excite the armature winding by the output of the battery and to supply the battery with the electric power generating output of the armature winding. A first detecting means detects a difference between an electric power storing voltage of the battery and a preset reference voltage. An electric power generation controlling means controls the operating frequency of the inverter in such a way that the voltage difference between the battery and the reference voltage is reduced.

SUMMARY OF THE INVENTION

50 [0008] In view of the above problem, the present invention has an object to provide an electric power generating device for vehicles which can stably and simply control the electric power generation performed by an induction type electric rotating machine working with a vehicle engine, the RPM of which varies frequently and speedily, without measuring the RPM of the induction type electric rotating machine.

[0009] This object is solved by the features of claim 1. Preferred embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] These and other objects, features and characteristics of the present invention will be appreciated from a

study of the following detailed description, the appended claims, and drawings, all of which form a part of this application. In the drawings:

FIG. 1 is a block diagram illustrating a circuit of an electric power generating device of an embodiment according to the present invention;

FIG. 2 is a schematic cross-sectional view illustrating induction machine 1;

FIG. 3 is a flow chart showing an operation of controlling electric power generation in a first embodiment;

FIGs. 4(a) and 4(b) show diagrams illustrating the single-phase equivalent circuits of induction machine 1;

## DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

[0011] Referring now to the appended drawings, description will be given to the induction machine type electric power generating device for vehicles according to the present invention.

[0012] FIG. 1 shows a block diagram of a first embodiment, FIG. 2 is a schematic, half cross-sectional view thereof taken in the axial direction, and FIG. 3 is a flow chart of the electric power generation control operation thereof.

[0013] The electric power generating device for vehicles comprises an induction machine 1, a 3-phase inverter circuit ("inverter" as referred to in the present invention) 2 and a controller ("electric power generation controlling means" as referred to in the present invention) 3.

[0014] The induction machine 1 is composed of a squirrel-cage rotor type 3-phase induction machine which is speed-increasingly driven by a crank shaft of an engine 10 of a vehicle through a belt at a pulley ratio of approximately 4. Armature winding ends U, V and W of the induction machine are connected to the respective phases of the AC ends of the inverter 2.

[0015] The 3-phase inverter circuit 2 is composed of 6 sets of MOS power transistors (hereinafter referred to as "transistors") 21 through 26 in 3-phase bridge rectifier connection.

[0016] More specifically, the armature winding end U is connected to the connecting point (AC end) of a U-phase inverter circuit through which a transistor 21 composing a switch at the higher potential side and a transistor 24 composing a switch at the lower potential side are connected in series; the armature winding end V is connected to the connecting point (AC end) of a V-phase inverter circuit through which a transistor 22 composing a switch at the higher potential side and a transistor 25 composing a switch at the lower potential side are connected in series; and the armature winding end W is connected to the connecting point (AC end) of a W-phase inverter circuit to which a transistor 23 composing a switch at the higher potential side and a transistor 26 composing a switch at the lower potential side are connected in series. The higher potential DC end of the inverter circuit of each phases is connected to the higher potential end of a battery (electric power storing means) 4 and also to one end of vehicle electric loads 5, while the lower potential DC end of the inverter circuit of each phase, the lower potential end of the battery 4, and the other end of the vehicle electric loads 5 are grounded.

[0017] The controller 3 is composed of an electronic circuit to which the voltage  $V_P$  of the armature winding end V ("electric power generating voltage" as referred to in the present invention), the terminal voltage  $V_B$  of the battery 4 ("electric power storing voltage" as referred to in the present invention), and the working signal voltage of an ignition switch (not illustrated)  $V_{IG}$  are inputted and from which the gate control voltages  $V_{g1}$  through  $V_{g6}$  of the 3-phase inverter circuit 2 are outputted. In this embodiment, the controller 3 is composed of a microcomputer device. The input interface of the microcomputer device is composed of an A/D converter for providing A/D conversion to these inputted voltages  $V_P$ ,  $V_B$  and  $V_{IG}$  respectively, and the output interface of the same is composed of a power amplifier for providing power amplification to these outputted six pulse voltages  $V_{g1}$  through  $V_{g6}$  respectively. As the compositions themselves of these interfaces have been known to public, the description thereof will be omitted herein.

[0018] As illustrated in FIG. 2, the induction machine 1 includes a housing 14 rotatably supporting a shaft 13 with a squirrel-cage rotor 11 and a pulley 12 fittingly mounted thereon. To the inner periphery of the housing 14 is fixed an armature core 16 wound with a 3-phase armature winding 15 therearound.

[0019] Numeral 17 denotes a bracket for closing an opening of the housing 14 and also for mounting the induction machine 1 to a vehicle body. Numerals 18 and 19 denote bearings. In structure, the cooling air taken from intake openings made in an end wall of the housing 14 and the bracket 17 is discharged from discharge openings made in the peripheral wall of the housing 14 and the bracket 17 by the rotation of a fan 20.

[0020] In the predetermined position of the outer periphery of the housing 14 is fastened a box-like case 14a having an electromagnetic wave shielding function. Within this case 14a are disposed the 3-phase inverter circuit 2 and the controller 3.

[0021] In this embodiment, the idling revolution number (RPM) of the engine 10 is set to 600 rpm, and the maximum RPM of the same is set to 6,000 rpm. The 3-phase armature winding 15 is of an 8-pole type with a short-pitch concentrated winding of  $2/3\pi$  [rad]. The armature core 16 has 24 slots, each slot, which is half-closed, has 6 conductors inserted thereinto.

[0022] Next, the operational principle of electric power generation will be described.

[0023] The engine 10 of the vehicle drives the squirrel-cage rotor 11 to rotate, while the controller 3 switches and controls the 3-phase inverter circuit 2 to apply the 3-phase AC voltage to each phase of the armature winding 15 of the induction machine. 1. Then, the device operates as an electric motor or an electric power generator as is publicly known according to the synchronous speed  $N_s$  computed from the frequency  $f$  of the applied voltage and the slip  $s$  ( $s = (N_s - N)/N$ ) computed from the RPM  $N$  of the squirrel-cage rotor 11. It is to be noted that the device operates as an electric power generator when the  $N_s < N$  is established.

[0024] Now, the operation of forming the 3-phase AC voltage by switching and controlling the 3-phase inverter circuit 2 will be described. The voltage  $V_u$  of the 3-phase armature winding end U is a half-wave-long voltage in the positive phase when the transistor 21 is in the ON position and, on the other hand, is a half-wave-long voltage in the (alternatingly) negative phase when the transistor 24 is in the ON position. The voltage  $V_v$  of the 3-phase armature winding end V is a half-wave-long voltage in the positive phase when the transistor 22 is in the ON position and, on the other hand, is a half-wave-long voltage in the (alternatingly) negative phase when the transistor 25 is in the ON position. The voltage  $V_w$  of the 3-phase armature winding end W is a half-wave-long voltage in the positive phase when the transistor 23 is in the ON position and, on the other hand, is a half-wave-long voltage in the (alternatingly) negative phase when the transistor 26 is in the ON position. Therefore, the 3-phase AC voltage can be formed by switching the transistors 21 and 24, the transistors 22 and 25 and the transistors 23 and 26 respectively in the phases opposite to each other and by switching the transistors 21, 22 and 23 in the phases different by 120 degrees from each other.

[0025] Next, an example of the electric power generation control achieved by the controller 3 will be described referring to the flow chart of FIG. 3.

[0026] First, in Step 101, the initial setting is made to set the frequency of the gate control voltages  $V_{g1}$  through  $V_{g6}$  to 144Hz, at which value the slip  $s$  is -10% when the engine is in idling.

[0027] Next, in Step 102, a judgement is formed whether or not an ignition switch (not illustrated) is in the ON position referring to whether or not the working signal voltage  $V_{IG}$  is larger than the preset voltage (5V in this case). When the judgment is negative, the next step is waited for.

[0028] On the other hand, when the judgement is positive, the device waits for a sufficient time required from the actuation of the ignition switch to the completion of the operation of the starter (0.5 second in this case) in Step 103 until the RPM of the engine is established.

[0029] Then, in Step 104, judgment is formed whether or not the battery voltage (electric power storing voltage)  $V_B$  is within the range of the preset voltage  $\Delta V$  from the reference voltage  $V_{ref}$ . When the battery voltage  $V_B$  is larger than the value " $V_{ref} + \Delta V$ ", it is judged that the electric power generation is not required, and then the preset value  $\Delta f$  is added to the existing frequency  $f$  in Step 106 to control the inverter 2 in Step 108, and then the electric power generating current  $I$  is detected in Step 109.

[0030] Incidentally, the electric power generating current  $I$  may be detected by using an electric current sensor or by the drop in voltage with a low resistance used for detecting electric current. Here, however, the difference between the detected electric power generating voltage  $V_P$  (here, the rectifying value of the  $V_P$  is computed by using software, and value  $V$  corresponding to the battery voltage  $V_B$  is obtained by multiplying the rectifying value of the  $V_P$  by the specified coefficient so that the rectifying value of the  $V_P$  can be on the same scale as that of the battery voltage  $V_B$ ) and the battery voltage  $V_B$  is employed as the electric power generating current. Further details about this point will be described later.

[0031] In Step 110, it is judged whether or not the detected or computed electric power generating current  $I$  exceeds the minimum electric current value  $I_{min}$ . When the judgement is positive, it is judged that the electric power generating current is still too large, that is, the level of the electric current generation is still too high, the process returns to Step 104, and again in Step 106, the frequency is increased and the slip is shifted in the positive direction to reduce the electric power generating current.

[0032] On the other hand, when the judgement formed in Step 110 is negative, that is, when the electric power generating current  $I$  is equal to or smaller than the minimum electric current value  $I_{min}$ , it is judged that, although the electric power generating current has sufficiently been lowered, the battery voltage  $V_B$  is still high, and the electric power generation should be stopped as the electric power generating current  $I$  and the slip should not be further reduced. Then, the 3-phase inverter circuit 2 is turned OFF (on-duty ratio: 0) in Step 112, and the process returns to Step 104.

it is needless to say that, even when the on-duty ratio is set to 0 in Step 112, the 3-phase inverter circuit 2 is tentatively actuated to detect electric current in Steps 118 and 119.

[0033] Here, taking Step 110 can prevent the slip from shifting in the positive direction and approaching the slip 0 in excess of the preset slip value by the increase in frequency in Step 106. As a result, the induction machine 1 can be prevented from erroneously being turned to the motor mode, providing a great effect. Furthermore, in this case, by setting the minimum electric current value  $I_{min}$  of the electric power generating current  $I$  (or the electric power generating voltage  $V_P$ ) to that in the part with the slip value of the electric power generating efficiency is maximum or in the part to which the slip value slightly shifts in the positive direction from the slip value at which the electric power generating effi-

ciency is maximum, the electric power generating operation is converged at the part with the maximum electric power generating efficiency is maximum as long as the situation permits, providing further effect.

[0034] In this embodiment, the electric power generating level is judged by the electric power generating current  $I$  in Steps 109 and 110. However, as the electric power generating current  $I$  (or the voltage difference " $V_P - V_B$ ") has a positive correlation with or proportional relationship to the electric power generating voltage  $V_P$  it is also acceptable that the electric power generating level is judged by detecting the electric power generating voltage  $V_P$  in Step 109 and judging in Step 110 whether or not the electric power generating voltage  $V_P$  is larger than the preset minimum electric power generating voltage  $V_{Pmin}$ .

[0035] Next, when it is judged in Step 104 that the battery voltage  $V_B$  is within the voltage range " $V_{ref} \pm \Delta V$ ", the frequency  $f$  is outputted as it is in Step 121.

[0036] On the other hand, if it is judged in Step 104 that the battery voltage  $V_B$  is below the voltage range " $V_{ref} \pm \Delta V$ ", it is judged that charging and electric power generation are not sufficient. Then, the preset value  $\Delta f$  is subtracted from the exciting frequency  $f$  in Step 114, and the inverter 2 is controlled accordingly in Step 116. Next, the electric power generating current  $I$  is detected in Step 118, and a judgment is formed in Step 119 whether or not the electric power generating current  $I$  is smaller than the preset maximum electric current value  $I_{max}$ . When the judgement is positive, it is judged that the electric power generating current can further be increased, and the process returns to Step 104. Then, again in Step 114, the frequency is reduced and the slip is shifted in the negative direction to increase the electric current generating current. On the other hand, when the judgement formed in Step 119 is negative, that is, if the electric power generating current  $I$  is equal to or larger than the value  $I_{max}$ , it is judged that the electric power generating current is too large, and the exciting frequency  $f$  is slightly increased in Step 120, and the process returns to Step 104 to protect the induction machine 1.

[0037] According to the composition and operation described above, the electric power generation can stably be controlled without any complicated and highly precise slip control by means of high-precision speed sensors.

[0038] Particularly, the electric power generation control can simply and stably be provided to a high-speed induction machine type electric power generating device driven by an engine for vehicles which has high speed, high fluctuation, driven by belt at a high pulley ratio and has multiple poles ("multiple poles" means 6 or more poles in the induction machine).

[0039] Here, the initial exciting frequency  $F_0$  is set to 144Hz which is approximately 10% lower than the synchronous speed corresponding to the idling revolution. The aim for this setting is to prevent the electric power generating device from at least being turned to be an electric motor due to the slip made to be negative in the idling revolution, that is, to prevent an increase in engine torque due to the electric motor operation during idling. Another effect can be obtained that the electric power generating device can be controlled within the frequency range in which the efficiency does not significantly lower (the range in which no remarkable degradation of the efficiency is caused by the normal range of slip 0 to  $\pm 10\%$ ).

[0040] In this embodiment, although the controller 3 is composed of a microcomputer device, it is natural that the controller 3 may be composed of a hardware logic circuit or an analogue circuit.

[0041] It is also acceptable that an engine RPM sensor or an engine ignition signal is obtained from an engine control unit (engine controlling microcomputer device normally abbreviated as "E.C.U.") and used for controlling the frequency. That is, the engine RPM can be detected from the engine RPM sensor or the engine ignition signal, and by multiplying the RPM by the minimum belt slip ratio and the maximum belt slip ratio, the maximum possible speed  $N_{max}$  and minimum possible speed  $N_{min}$  of the induction machine 1 can be determined. Accordingly, by setting the synchronous speed  $N_0$  obtained from the frequency of the gate control voltages  $V_{g1}$  through  $V_{g6}$  to be at least lower than the maximum possible speed  $N_{max}$ , the slip  $s$  can be negative, that is, the device can be turned to be the electric power generating mode.

[0042] A case has been described above where the maximum possible speed  $N_{max}$  and minimum possible speed  $N_{min}$  of the induction machine 1 computed from the engine speed were determined to maintain the electric power generating mode. In addition, a case where the revolution number of the induction machine 1 computed in the above way is actively used will be described below.

[0043] Slip command value  $S$  of the induction machine 1 is computed from the function of the difference between the battery voltage  $V_B$  and the reference value  $V_{ref}$  thereof and the induction machine RPM  $N$ . Furthermore, the frequency of the inverter is determined from the slip command value  $S$  and the present induction machine RPM  $N$  to control the electric power generation to the optimum value.

[0044] In this case, accurate induction machine RPM can not be obtained due to some difference in the pulley size according to the type of the electric power generating device and the slip of the belt. However, by correcting the frequency of the inverter determined in the above way with the deviation of the actually measured value from preset value of the battery voltage, the device can exactly be controlled to the most suitable electric power generating state in a short time without using any dedicated RPM sensor for measuring the RPM of the induction machine 1, providing an excellent effect.

[0045] Furthermore, by setting the synchronous speed  $N_0$  to be at least equal to or lower than the minimum possible speed  $N_{min}$ , the electric power generating operation can be performed at a high efficiency.

[0046] In the above case, the maximum possible speed  $N_{max}$  and minimum possible speed  $N_{min}$  of the induction type electric power generating device computed from the engine speed are determined to maintain the electric power generating mode. Now, a case will be described where the revolution number of the induction type electric power generating device computed in the above way is actively used.

[0047] Slip command value  $S$  of the induction type electric power generating device is computed from the function of the difference between the battery voltage  $V_B$  and the reference value  $V_{ref}$  thereof and the revolution number  $N$  of the induction type electric power generating device.

[0048] Then, the frequency of the inverter is determined from the slip command value  $S$  and the present revolution number  $N$  of the induction type electric power generating device to control the electric power generation to the optimum state.

[0049] It is to be noted that the accurate revolution number of the induction type electric power generating device can not be detected from the engine speed due to the difference in the type of the electric power generating device, the diameter of the pulley, the slip of the belt, etc.

[0050] However, as described above, by determining the frequency of the inverter by the deviation of the actually measured value from the preset value of the battery voltage, the device can exactly be controlled to the optimum electric power generating state in a short time without using any dedicated RPM sensor for measuring the revolution number of the induction type electric power generating device.

[0051] In FIG. 5(a),  $E$  denotes an assumption that the battery voltage  $V_B$  is an AC sinusoidal electric power source. Two resistances  $r_i$  are the resistance components of the battery 4 and the inverter 2.  $Z_1$  stands for the impedance of the armature coil (primary side),  $r_1$  denotes the resistance amount thereof, and  $x_1$  denotes the reactance amount thereof.  $Z_2$  denotes the impedance of the rotor side (secondary side),  $r_2$  denotes the resistance amount thereof, and  $x_2$  denotes the reactance amount thereof.  $Z_0$  denotes the exciting impedance,  $r_0$  denotes the resistance amount thereof, and  $x_0$  denotes the reactance amount thereof. As the slip  $s$  is negative, electric current flows from the induction machine 1 to the battery side. Theoretically, as the  $r_i$  is known, the detection can be made according to the following equation: Electric power generating current = (Electric power generating voltage  $V_p$  (scale converted) - Battery voltage  $V_B$ ) /  $2r_i$ .

[0052] The electric power generating current  $I$  can easily be computed as the functional value of the values  $V_p$ ,  $Z_0$ ,  $Z_1$  and  $Z_2$  from the equivalent circuit illustrated in FIGs. 5(a) and 5(b). As the values except for the slip  $s$ , the electric power generating voltage  $V_p$  and the electric power generating current  $I$  are known and constant, the slip  $s$  can easily be computed from the values  $V_p$  and  $I$  based on the equivalent circuit illustrated in FIGs. 5(a), 5(b). Furthermore, by storing the map indicating the relation among the values  $V_p$ ,  $I$  and  $s$  in the microcomputer, the slip  $s$  can easily be searched from the values  $V_p$  and  $I$ .

[0053] For reference, if the value  $Z_0$  is omitted to simplify the computation and the power factor is also ignored in FIGs. 5(a), 5(b), the above equation can be reduced to:  $I = V_p / (r_1 + j(x_1 + x_2) + r_2/s)$ . From this equation, it is understood that the electric power generating current  $I$  increases when the value  $s$  shifts from 0 in the negative direction and, on the other hand, the electric power generating current  $I$  decreases when the value  $s$  approaches to 0 from the negative direction. However, as there is a high efficiency electric power generation range in the zone where the value  $s$  is near 0, it is preferable that the slip  $s$  should be set within the negative value range near 0 (-5% to -15% as an example) when the electric power current  $I$  can be further increased. It is also preferable that the exciting frequency  $f$  should be increased to bring the slip  $s$  near 0.

## Claims

1. An electric power generating device for providing the DC supply current of a vehicle, comprising:

[a] an induction type electric rotating machine (1) including an armature (16) having an armature winding (15) and a rotor (11) coupled to an engine (10) of said vehicle;

[b] a vehicle battery (4) charged by the electric power generated by said electric machine (1);

[c] an inverter (2) an alternating current side of which is connected to an end of said armature winding and a direct current side of which is connected to said battery (4) to excite said armature winding by the output of said battery (4) and to supply said battery with the electric power generated in said armature winding;

[d] first detecting means (3; step 104) for detecting an output voltage ( $V_B$ ) of said battery (4); and

[e] electric power generation controlling means (3; steps 106, 108, steps 114, 116) for controlling the operation frequency ( $f$ ) of said inverter (2) so as to control said battery output voltage ( $V_B$ ),  
characterized by

[f] second detecting means (3, step 109, 118) connected to said controlling means for detecting the value of

the generator current (I) supplied to said battery (4);

[g] said controlling means controlling said inverter (2) in such a way that

[g1] the operation frequency (f) of said inverter (2) is increased by a preset amount ( $\Delta f$ ) if the battery voltage (VB) is higher than a preset reference voltage (Vref) plus a preset voltage level ( $\Delta V$ ), and

the operation of said inverter (2) is stopped if the detected generator current (I) is lower than a predetermined minimum value (Imin),

[g2] the operation frequency (f) of said inverter (2) is decreased by a preset amount ( $\Delta f$ ) if said battery voltage (VB) is lower than said preset reference voltage (Vref) minus said preset level ( $\Delta V$ ) and the operation frequency

(f) of said inverter (2) is increased by a preset amount ( $\Delta f$ ) if the detected generator current is higher than a predetermined maximum value (Imax).

2. Electric power generating device according to claim 1 characterized in that said electric power generation controlling means (3; step 204) detects the electric power generating voltage ( $V_p$ ) of the armature winding (15) of said induction type electric rotating machine (1) and controls said operating frequency (f) based on said electric power generating voltage ( $V_p$ ).

3. Electric power generating device according to claim 1 or 2, characterized in that said second detecting means (3) computes said generator current (I) based on the difference between said electric power generating voltage ( $V_p$ ) and the battery voltage ( $V_B$ ).

4. Electric power generating device according to one of the preceding claims, characterized in that said rotor (11) of said induction type electric rotating machine (1) is a squirrel-cage rotor and driven by said engine (10) through a belt and pulleys.

5. Electric power generating device according to one of the preceding claims, characterized in that said inverter (2) includes six MOS power transistors (21 - 26) in three-phase bridge connection.

#### Patentansprüche

1. Elektrische Energieversorgungsvorrichtung zum Liefern des Versorgungs-Gleichstroms eines Fahrzeugs, die aufweist:

[a] eine elektrische Induktionsmaschine (1), die einen Ständer (16) mit einer Ständerwicklung (15) und einen Läufer (11) beinhaltet, der mit einem Motor (10) des Fahrzeugs gekoppelt ist;

[b] eine Fahrzeugbatterie, die mit der von der elektrischen Maschine (1) erzeugten Energie geladen wird;

[c] einen Wechselrichter (2), dessen Wechselstromseite mit einem Ende der Ständerwicklung verbunden ist und dessen Gleichstromseite mit der Batterie (4) verbunden ist, um die Ständerwicklung durch das Ausgangssignal der Batterie (4) zu erregen und die Batterie mit der von der Ständerwicklung erzeugten elektrischen Energie zu versorgen;

[d] eine erste Erfassungseinrichtung (3; Schritt 104) zum Erfassen einer Ausgangsspannung (VB) der Batterie; und

[e] eine Einrichtung (3; Schritte 106, 108, Schritte 114, 116) zum Steuern eines Erzeugens der elektrischen Energie, die die Betriebsfrequenz (f) des Wechselrichters (2) steuert, um die Batterieausgangsspannung (VB) zu steuern, gekennzeichnet durch

[f] eine zweite Erfassungseinrichtung (3, Schritt 109, 118), die mit der Steuereinrichtung verbunden ist, zum Erfassen des Werts des Generatorstroms (I), der der Batterie (4) zugeführt wird;

[g] wobei die Steuereinrichtung den Wechselrichter (2) auf eine derartige Weise steuert, daß

[g1] die Betriebsfrequenz (f) des Wechselrichters (2) um einen im voraus festgelegten Betrag ( $\Delta f$ ) erhöht wird, wenn die Batteriespannung (VB) höher als eine im voraus festgelegte Referenzspannung (Vref) plus einem im voraus festgelegten Spannungspegel ( $\Delta V$ ) ist, und der Betrieb des Wechselrichters (2) gestoppt

wird, wenn der erfaßte Generatorstrom (I) niedriger als ein vorbestimmter Minimalwert ( $I_{\min}$ ) ist,

[g2] die Betriebsfrequenz (f) des Wechselrichters (2) um einen im voraus festgelegten Betrag ( $\Delta f$ ) verringert wird, wenn die Batteriespannung (VB) niedriger als die im voraus festgelegte Referenzspannung ( $V_{\text{ref}}$ ) minus dem im voraus festgelegten Pegel ( $\Delta V$ ) ist, und die Betriebsfrequenz (f) des Wechselrichters (2) um einen im voraus festgelegten Betrag ( $\Delta f$ ) erhöht wird, wenn der erfaßte Generatorstrom höher als ein vorbestimmter Maximalwert ( $I_{\max}$ ) ist.

2. Elektrische Energieversorgungsvorrichtung nach Anspruch 1, *dadurch gekennzeichnet*, daß die Einrichtung (3; Schritt 104) zum Steuern eines Erzeugens der elektrischen Energie die eine elektrische Energie erzeugende Spannung ( $V_p$ ) der Ständerwicklung (15) der elektrischen Induktionsmaschine (1) erfaßt und die Betriebsfrequenz (f) auf der Grundlage der eine elektrische Energie erzeugenden Spannung ( $V_p$ ) steuert.
3. Elektrische Energieversorgungsvorrichtung nach Anspruch 1 oder 2, *dadurch gekennzeichnet*, daß die zweite Erfassungseinrichtung (3) den Generatorstrom (I) auf der Grundlage der Differenz zwischen der eine elektrische Energie erzeugenden Spannung ( $V_p$ ) und der Batteriespannung ( $V_B$ ) berechnet.
4. Elektrische Energieversorgungsvorrichtung nach einem der vorhergehenden Ansprüche, *dadurch gekennzeichnet*, daß der Läufer (11) der elektrischen Induktionsmaschine (1) ein Kurzschlußläufer ist und über einen Riemen und Riemenscheiben von dem Motor (10) angetrieben wird.
5. Elektrische Energieversorgungsvorrichtung nach einem der vorhergehenden Ansprüche, *dadurch gekennzeichnet*, daß der Wechselrichter (2) sechs MOS-Leistungstransistoren (21 bis 26) in einer Dreiphasen-Brückenschaltung beinhaltet.

## Revendications

1. Dispositif de génération de puissance électrique destiné à fournir le courant d'alimentation DC d'un véhicule, comprenant :

[a] une machine électrique rotative du type à induction (1) comprenant un induit (16) ayant un enroulement d'induit (15) et un rotor (11) accouplés à un moteur (10) dudit véhicule ;

[b] une batterie de véhicule (4) chargée par la puissance électrique générée par ladite machine électrique (1) ;

[c] un onduleur (2) ou un côté courant alternatif est connecté à une extrémité dudit enroulement d'induit et dont un côté courant continu est connecté à ladite batterie (4) pour exciter ledit enroulement d'induit au moyen de la sortie de ladite batterie et pour fournir à ladite batterie ladite puissance électrique générée dans ledit enroulement d'induit ;

[d] un premier moyen de détection (3 ; étape 104) destiné à détecter une tension de sortie (VB) de ladite batterie (4) ; et

[e] un moyen de contrôle de génération de la puissance électrique (3 ; étapes 106, 108, étapes 114, 116) destiné à contrôler la fréquence fonctionnelle (f) dudit onduleur (2) de manière à contrôler ladite tension de sortie de batterie (VB),

caractérisé en ce que

[f] le second moyen de détection (3 ; étapes 109, 118) est connecté audit moyen de contrôle pour détecter la valeur du courant généré (I) fourni à ladite batterie (4) ;

[g] ledit moyen de contrôle contrôle ledit onduleur (2) d'une manière telle que

[g1] la fréquence fonctionnelle (f) dudit onduleur (2) est augmentée d'une quantité pré-établie ( $\Delta f$ ) si la tension de batterie (VB) est plus élevée qu'une tension de référence pré-établie ( $V_{\text{ref}}$ ) plus un niveau de tension est pré-établi ( $\Delta V$ ), et

le fonctionnement dudit onduleur (2) est arrêté si le courant généré détecté (I) est plus faible qu'une valeur minimale prédéterminée ( $I_{\min}$ ),

[g2] la fréquence fonctionnelle (f) dudit onduleur (2) est diminuée d'une quantité pré-établie ( $\Delta f$ ) si ladite tension de batterie (VB) est plus faible que ladite tension de référence pré-établie ( $V_{\text{ref}}$ ) moins ledit niveau pré-établi ( $\Delta V$ ) et la fréquence fonctionnelle (f) dudit onduleur (2) est augmentée d'une quantité prédéterminée ( $\Delta f$ ) si le courant généré détecté est plus élevé qu'une valeur maximale prédéterminée ( $I_{\max}$ ).

2. Dispositif de génération de puissance électrique selon la revendication 1, caractérisé en ce que ledit moyen de contrôle de la génération de la puissance électrique (3 ; étape 204) détecte la tension de génération de la puis-



sance électrique ( $V_p$ ) de l'enroulement d'induit (15) de ladite machine électrique rotative du type à induction (1) et contrôle ladite fréquence fonctionnelle ( $f$ ) sur la base de ladite tension de génération de puissance électrique ( $V_p$ ).

3. Dispositif de génération de puissance électrique selon la revendication 1 ou 2 caractérisé en ce que ledit second moyen de détection (3) calcule ledit courant généré ( $I$ ) sur la base de la différence entre ladite tension de génération de puissance électrique ( $V_p$ ) et la tension de batterie ( $V_B$ ).
4. Dispositif de génération de puissance électrique selon l'une des revendications précédentes, caractérisé en ce que ledit rotor (11) de ladite machine électrique rotative de type à induction (1) est un rotor en cage d'écureuil et est entraîné par ledit moteur (10) par l'intermédiaire d'une courroie et de poulies.
5. Dispositif de génération de puissance électrique selon l'une des revendications précédentes, caractérisé en ce que ledit onduleur (2) comprend six transistors MOS de puissance (21 - 26) en connexion en pont à trois phases.

FIG. 1

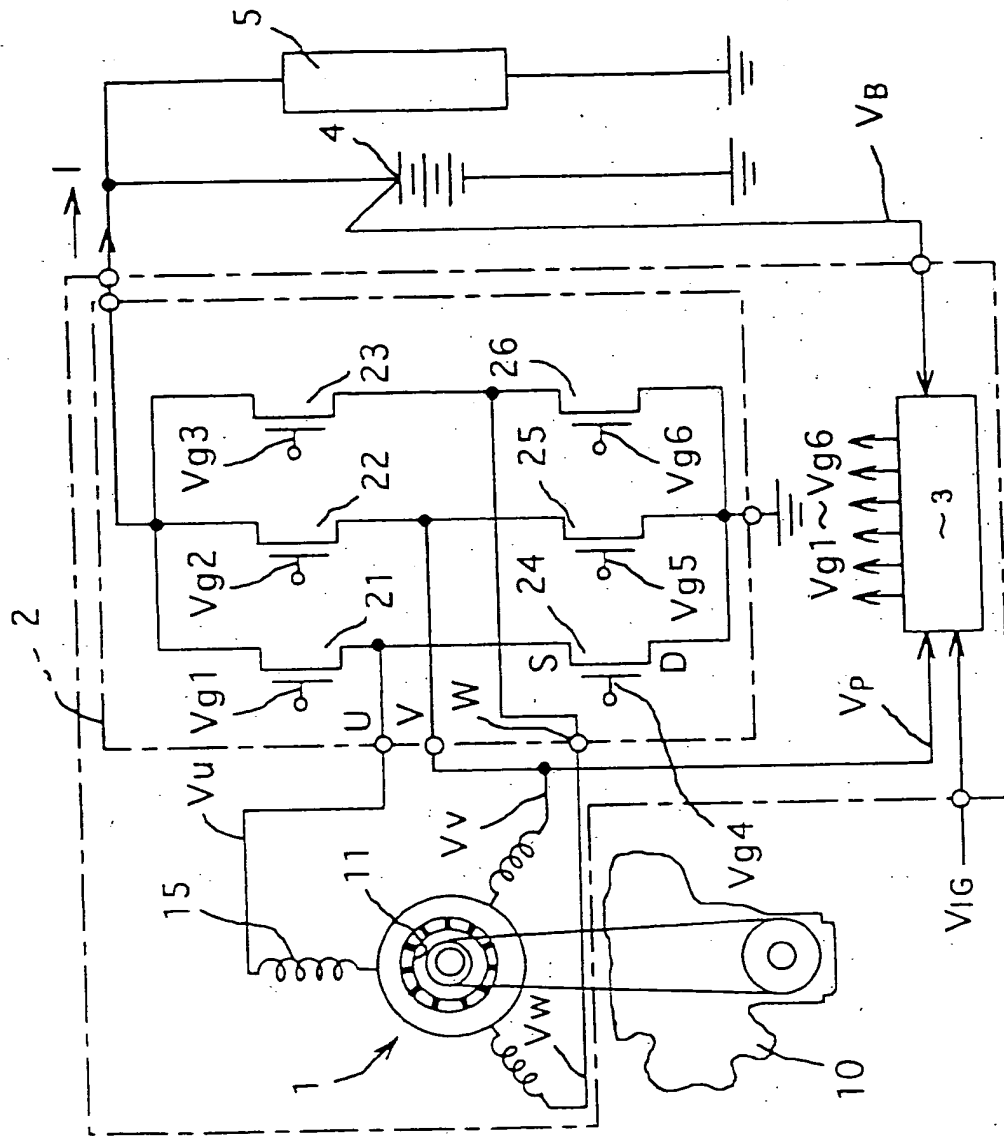


FIG. 2

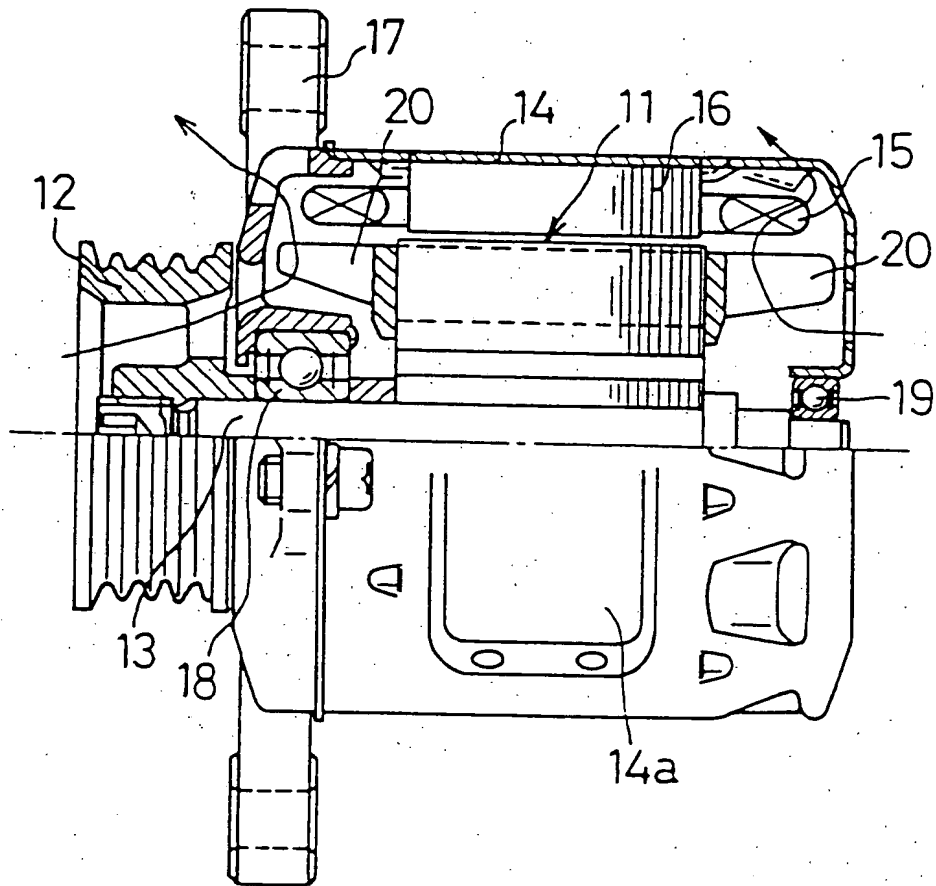


FIG. 3

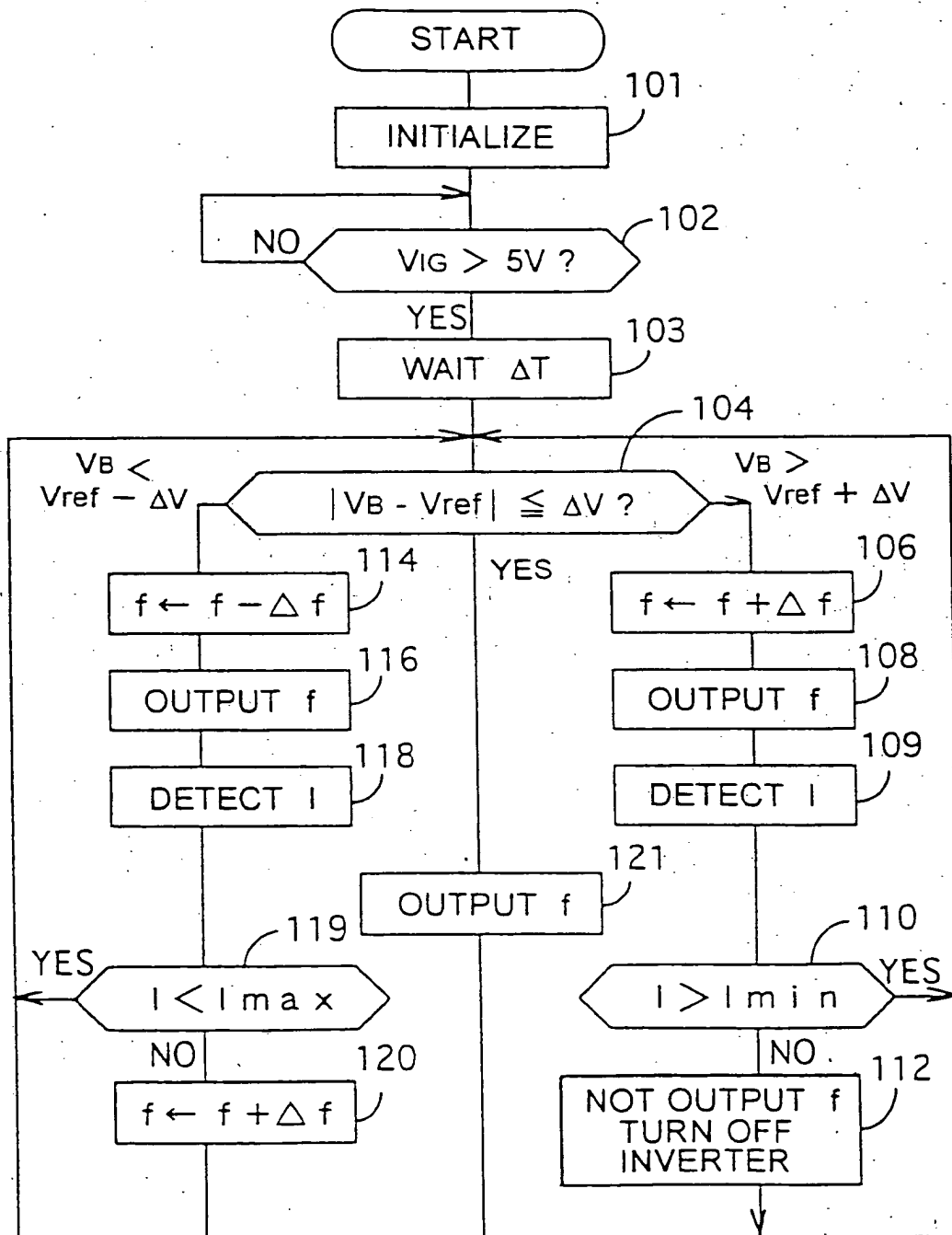


FIG. 4(a)

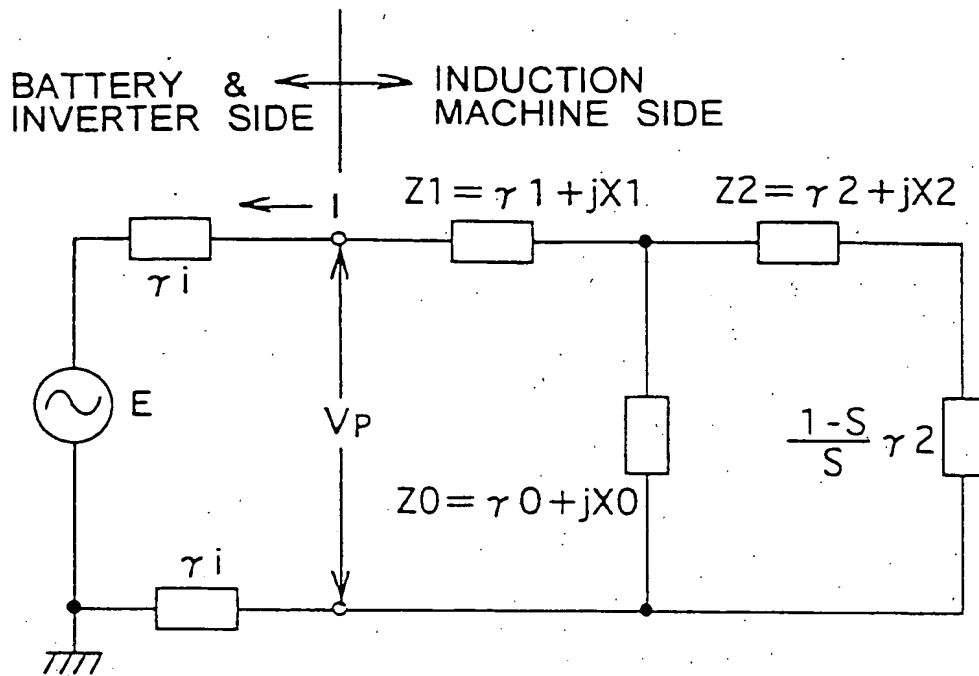
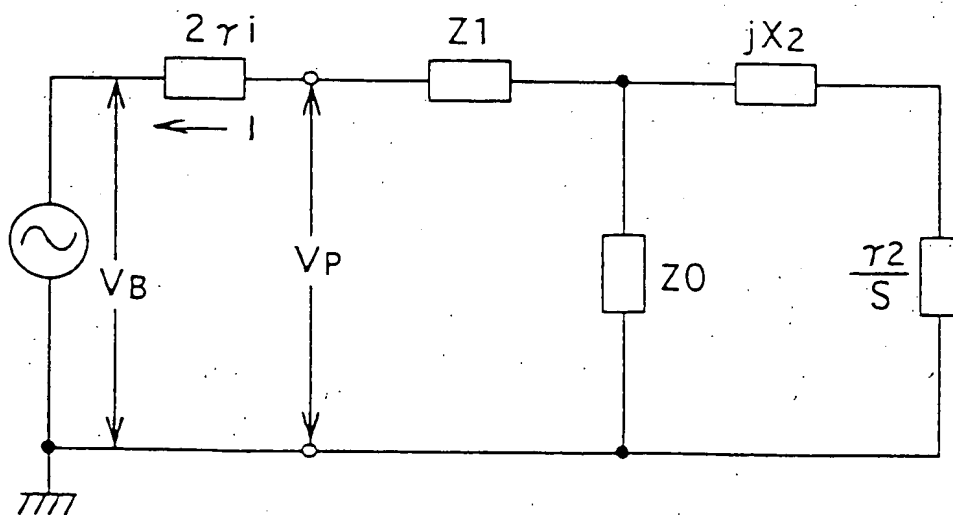


FIG. 4(b)



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